ONTARIO MINISTRY OF ENVIRONMENT
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A Laboratory Study

on

THE TREATMENT OF SUGAR BEET WASTES

from

CANADA AND DOMINION SUGAR COMPANY, LIMITED

CHATHAM, ONTARIO

A report prepared by

PURIFICATION PROCESSES BRANCH

ONTARIO WATER RESOURCES COMMISSION

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REPORT

Ontario Water Resources Commission

Municipality Chatham Date of Inspection November 13, 1963.

Re: A LABORATORY STUDY ON THE TREATMENT OF SUGAR BEET WASTES FROM CANADA AND DOMINION SUGAR COMPANY, LIMITED.

Field Inspection by Report by A. Oda, P. Eng.

INTRODUCTION

At the request of Proctor & Redfern Limited, some laboratory tests were conducted by the staff of the Ontario Water Resources Commission on the samples of flume wastes. The samples were collected on November 13, 1963 from the sugar beet processing operations at the Canada and Dominion Sugar Company, Limited, Chatham. The objectives of these tests were:

a) to determine the nature of supernatant from the waste sample after it has been subjected to simple settling.

b) to evaluate the effects of various coagulant chemicals on the solids settling and the clarification of the sample.

c) to obtain some pertinent information regarding the settleability of the suspended solids in the waste for the design of a clarifier.

CHARACTERISTICS OF FLUME WATER

Flume water which is said to constitute approximately 70 to 80 percent of the total water consumption in the plant is used to transport beets from the storage area into the factory and also to wash the beets free of any adhering dirt and vegetable matter. A sample of flume water contains considerable quantity of leaves, small beet particles, beet rootlets, and

soil washed off the beets. Its strength varies according to the quality of beets and the amount of dirt and extraneous matter that is delivered with the beets. Under the wet weather conditions, the amount of suspended solids in the flume water can be expected to increase very markedly. The amount of biochemical oxygen demand (BOD) usually varies between 200 and 300 parts per million (p.p.m.), but this, too, depends on the quality of beets delivered to the plant. If the beets are bruised, frozen or spoiled, this would tend to increase the sugar content in the flume water and therefore higher values of BOD can be expected.

The analyses of flume water sample collected on November 13, 1963 indicated the following:

5-day BOD	195 to 235 ppm
suspended solids	2456 to 2752 ppm
turbidity	>800 to 1680 ppm
pH	6.9 to 6.6 *

* The pH values were found to decrease gradually, the longer the samples were kept.

PROCEDURE

1) Settling Tests

A well-agitated sample of flume water was placed in a 4-litre graduated cylinder and allowed to settle. At pre-determined intervals, samples for suspended solids analysis were withdrawn by means of a pipette. All of these samples were taken in the similar manner from about four inches below the surface of the liquid.

The analytical results are presented in Table I.

2) Coagulation Tests

Jar tests were conducted in the usual manner using varying dosages of alum. The samples were given 1.5 minutes of rapid-mix, 10 to 15 minutes of gentle stirring and then allowed to settle for 20 to 30 minutes before analyses. Various dosages of coagulant aids were added in order to evaluate their effects on alum coagulation.

3) Coagulation and Settling with Polyelectrolytes

Samples of waste water were placed in a graduated cylinder equipped with a stopper and varying dosages of polyelectrolytes were added. The cylinders were stoppered and given a gentle shaking in a semi-rotary motion for about one to two minutes. Then the samples were allowed to stand and turbidity analyses were performed on the supernatant.

The settled supernatant from the sample treated with 1.5 p.p.m. Superfloc 16 was given further treatment with 100 p.p.m. alum (Jar Test).

It should be noted that the temperatures in nearly all of the samples which were used in the coagulation tests were below 10°C.

RESULTS

The results of all the laboratory tests are tabulated and can be found in the Appendix.

DISCUSSION OF RESULTS

1) Settling Tests

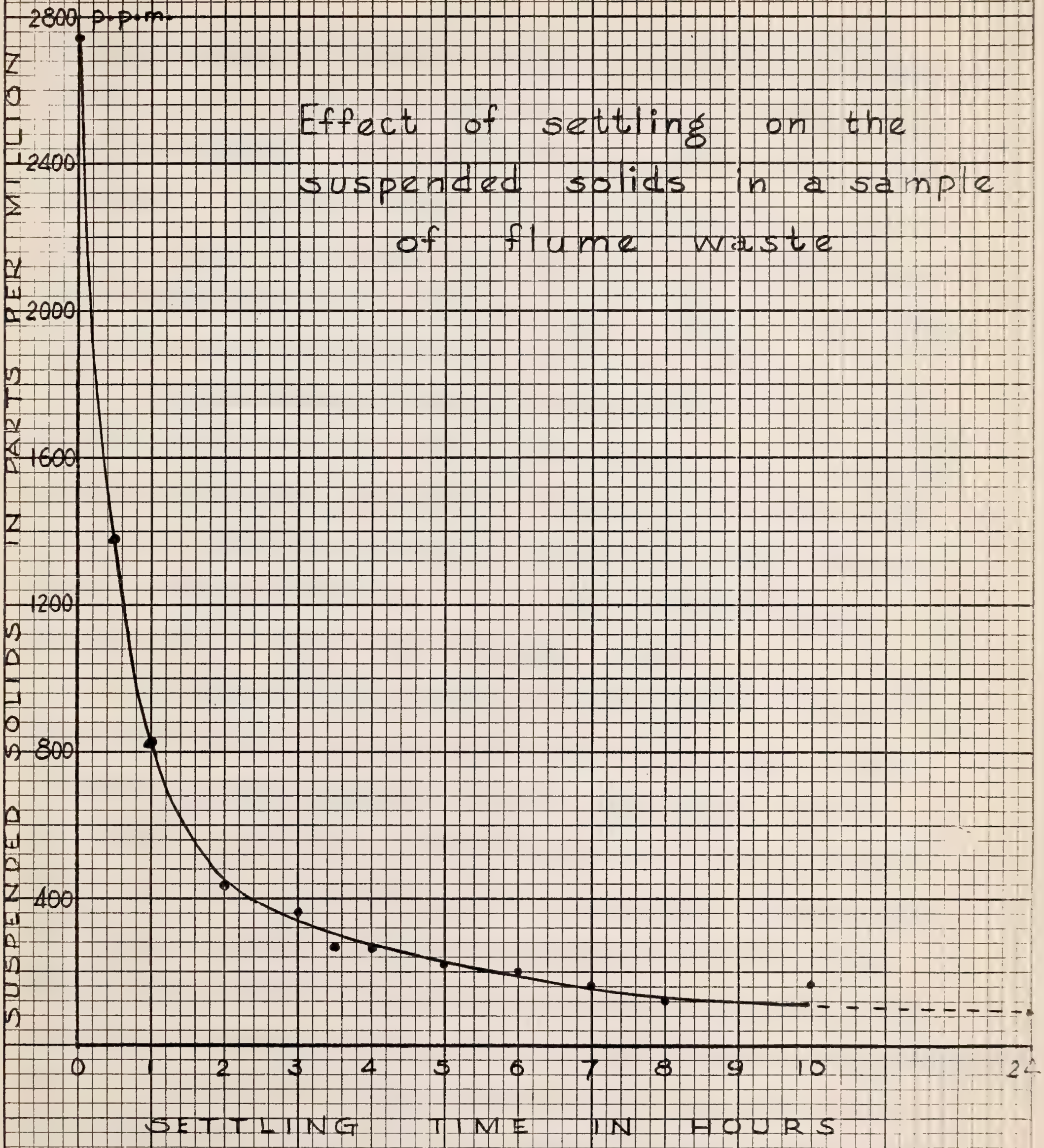
The results of these tests (see Table I) indicate that the rate of settling for the suspended solids in the sample of flume water was very rapid during the first two hours and then the settling subsided very markedly after this interval. It is noted that about 50 percent of the settleable solids was removed within the first 30 minutes from the upper reaches of the liquid in the test cylinder; at the end of one hour, the amount removed was approximately 70 percent and at the end of two hours, it was about 84 percent. The amount of solids removed by subsidence after 24 hours of settling was about 96.6 percent.

A graphical representation of the test results shows very clearly that the bulk of the settleable solids removed by subsidence was within 4 hours after which the amount of material settling out was not significant.

Another noteworthy feature of the settling tests was the fact that there was no significant reduction in the BOD even though a good reduction in suspended solids was achieved. The analyses of the supernatant of the sample subjected to a 24-hour settling period indicated a BOD value of about 195 ppm which is essentially the same as the BOD in the waste sample containing high suspended solids.

2) Coagulation Tests

Floc formation did not take place very readily when the jar tests were performed on the fresh sample of waste. A dosage of 100 p.p.m. alum



Effect of settling on the suspended solids in a sample of flume waste

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was required before any appreciable flocculation was apparent. The floc particles were very fine; they seemed to be very light and were somewhat very slow in settling. At a dosage of 150 p.p.m. alum, there was a slight improvement in flocculation but the clarity in the supernatant was not as good as expected. The addition of 0.5 p.p.m. Separan AP-30 with 150 p.p.m. alum produced better floc formation and noticeable reduction in turbidity, whereas the use of Nalcolyte 110 did not seem to help very much.

It is interesting to note that the sample which has been kept in the refrigerator for a period of four or five days showed a much better response to alum treatment. For example, a five-day old sample produced good floc formation with 75 p.p.m. alum and a comparatively better clarity was obtained in the supernatant than when the test was carried out with a dosage of 100 p.p.m. alum in the fresh sample of waste.

The addition of very small dosages of coagulant aids especially activated silica and those containing polyacrylamides was very effective in promoting good floc formations. Heavy floc particles were produced very rapidly and the sample was clarified within 2 or 3 minutes. The best clarity was observed in the sample treated with 100 p.p.m. alum and 2 p.p.m. activated silica, and the turbidity in the supernatant was found to be about 26 p.p.m. This was the lowest level of turbidity attained by chemical coagulation. Equivalent amounts of other coagulant aids containing polyacrylamides used in conjunction with alum also produced about the same degree of clarity in the supernatant. Because of the high turbidity in the raw waste samples,

large heavy floc particles were developed in the tests involving alum - coagulant aid treatment. These heavy particles had a tendency to settle out immediately during the flocculation process and leave behind much of the finer particles in suspension.

Although it was possible to reduce the suspended solids and therefore clarify the samples by means of chemical coagulation, the amount of BOD that can be removed by this method seems to be limited. The analysis of the supernatant from the sample treated with alum and activated silica indicated a BOD of 150 p.p.m. Assuming that the sample of flume waste before treatment contained an average BOD of 200 p.p.m., this would mean that only about 25 percent of the BOD in the waste can be removed by coagulation.

The tests involving the use of lime as coagulant aid did not produce very good clarity. The lime seemed to interfere with alum coagulation. The floc particles seemed to be much lighter and settling was very much slower.

3) Coagulation and Settling with Polyelectrolytes

All of the polyelectrolytes except Aerofloc 550 and Swift's Colloid 5S given in Table III have polyacrylamide as one of their principal ingredients. Aerofloc 550 consists of hydrolyzed polyacrylonitrite and Colloid 5S is said to be a polymeric substance of proteinic nature. Although these two chemicals produced some reactions in these tests, they were found to be less effective than the polyacrylamides. The merits of these two were considered because of their low relative costs as compared to that of the polyacrylamides.

One of the interesting features of the polyelectrolytes notably those containing polyacrylamides is that the speed at which the agglomeration of solids takes place in the waste sample. As soon as small dosages of the chemical are mixed together with the sample of waste and then allowed to stand, the fine suspended particles can be seen to agglomerate into larger particles and fall to the bottom very quickly. A definite improvement in the clarity can be observed in the supernatant in a matter of two or three minutes whereas under natural subsidence, it may take more than three or four hours to reach the same level of clarity.

With the exception of Aerofloc 550 and Colloid 5S, the reactions of the polyelectrolytes were similar in nature. The degree of clarity obtained in the supernatant was dependent on the amount of chemical used. However it appears that the amount of turbidity which can be removed by this method of treatment is limited. This is illustrated in Table IV which shows the effects of adding varying dosages of Superfloc 16 on the turbidity levels obtained in the respective supernatant samples. The turbidities were measured after the samples had been allowed to stand for about 30 minutes. It can be seen that any addition of reagent above a dosage of 2.0 p.p.m. does not seem to produce any significant improvements in the turbidity level.

The sample which was treated first with 1.5 p.p.m. Superfloc 16 and then given a further treatment with 100 p.p.m. alum showed a definite improvement in clarity. The turbidity was reduced from 160 p.p.m. to 21 p.p.m. This is only slightly better than the results obtained in other tests involving normal jar test procedures. The BOD in the supernatant was reduced to 165 p.p.m.

SUMMARY AND CONCLUSIONS

This report presents the details and the summary of results from a series of laboratory tests which were conducted on samples of flume wastes obtained from a sugar beet processing plant at Chatham. This study has dealt with the possible treatment methods which could be considered to remove suspended solids and to reduce BOD in the wastes and it has involved settling tests and coagulation tests with alum and other flocculants.

The results of the settling tests show that about 84 percent of the suspended solids can be removed from the wastes within two hours by natural subsidence. However, in spite of the fact that about 97 percent of the suspended solids was removed after a 24-hour settling period, there was no significant reduction of BOD in the supernatant.

Fresh samples of wastes did not seem to respond very well to alum treatment. Better flocculation and hence better clarity were obtained with much lower dosages of alum in portions of the samples which had been kept in the refrigerator for a period of four or five days.

Alum coagulation was greatly enhanced by the use of very small dosages of activated silica and polyacrylamide type of coagulant aids. These aids increased the rate of flocculation and settling, but they seemed to produce extremely heavy floc particles which settled out too quickly leaving behind myriads of very fine flocs in suspension. Best clarity in the supernatant was obtained by coagulation with 2 p.p.m. activated silica and 100 p.p.m. alum. Polyacrylamides were also found to be as equally as effective in promoting good flocculation with alum.

In spite of the unusually good turbidity removal in the sample treated with alum and activated silica, the analysis of the supernatant showed that the reduction in the BOD concentration was only 25 percent.

The use of lime as a coagulant aid seemed to interfere with alum coagulation.

Polyelectrolytes which contain polyacrylamides were found to be very effective in settling out the suspended solids very quickly. A dosage of about 2 p.p.m. added to the flume waste samples was sufficient to remove almost all of the solids within two or three minutes.

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APPENDIX

1) Table I Results of the Settling Tests

2) Table II Coagulation Tests

3) Table III Coagulation and Settling with Polyelectrolytes

4) Table IV Effect of Varying Dosages of Polyelectrolytes on the Turbidities in the Supernatant

5) Analytical Results

   i) Settling Tests

   ii) Coagulation Tests

TABLE I

RESULTS OF THE SETTLING TESTS

Elapsed Time	Suspended Solids	Temperature	Remarks
0 hrs.	2752 p.p.m.	6.9°C	BOD - 195 p.p.m. Turbidity - 1680 units
0.5	1376	10.0	
1.0	830	11.2	
2.0	440	14.5	
3.0	362	---	
3.5	270	17.0	
4.0	274	17.6	
5.0	224	18.6	
6.0	202	19.5	
7.0	164	20.6	
8.0	124	21.0	
10.0	162	22.0	
24.0	94	24.0	BOD - 195 p.p.m. Turbidity - 75 units

Effect of settling on the suspended solids in a sample of flume waste.

TABLE II

COAGULATION TESTS

Analyses of flume wastes before treatment

5-day BOD - 195 to 230 p.p.m.
Suspended solids - 2456 to 2752 p.p.m.
Turbidity - > 1000 p.p.m.
pH - 6.9 to 6.6

Chemical	Dosage p.p.m.	Turbidity	pH	Remarks
1. Alum	100	98	6.5	formation of very fine floc poor clarification
2. Alum	150	53	6.0	very heavy floc particles poor clarity in the supernatant
3. Alum Separan AP-30	150 0.5	32	6.2	good flocculation very heavy floc particles
4. Alum Nalcolyte 110	150 5	63	6.2	good flocculation, but poor settling

The following tests were conducted on portions of the sample which had been kept in the refrigerator for at least five days.

Chemical	Dosage p.p.m.	Turbidity	pH	Remarks
5. Alum	75	84	6.4	good flocculation, but rather poor clarity in the supernatant
6. Alum	100	74	6.4	good flocculation BOD - 180 p.p.m.
7. Alum	125	58	6.3	formation of very heavy floc particles which settled out very rapidly BOD - 225 p.p.m.
8. Alum	150	37	6.2	similar observations as in (7) except that there was a much better clarity in the supernatant
9. Alum	175	28	6.1	similar remarks as in (8) BOD - 165 p.p.m.

TABLE II (cont'd.)

Chemical	Dosage p.p.m.	Turbidity	pH	Remarks
10. Alum	200	26	6.0	same remarks as in (8) greater volume of settled sludge.
11. Alum Activated Silica	100 2	26	6.3	floc formation and settling seemed to take place very rapidly large volume of sludge BOD - 150 p.p.m.
12. Alum Separan NP-10	100 1	40	6.2	same remarks as in (11) but the clarity in the supernatant was not as good.

Tests involving other coagulant aids such as Separan AP-30, Superfloc 16, and N-11 which also consists of polyacrylamide produced effective flocculation and reasonably good clarification. The turbidity levels in the supernatants were generally about 30 to 40 p.p.m. silica units.

13. Alum	100	--		Lime seems to slow the reaction down and keep the floc particles in suspension longer.
14. Alum Lime	100 20	--		same observations as in (13)

Other coagulant aids such as Nalco 600 and Wisprofloc were studied, but they seemed to have very little effect in improving flocculation.

TABLE III

COAGULATION AND SETTLING WITH POLYELECTROLYTES

The following is the list of polyelectrolytes which were used in these tests:

Polyelectrolyte	Supplier
Aerofloc 550	Cyanamid
Aerofloc 3171	Cyanamid
Colloid 5S	Swift's
M-11	Morningstar-Paisley
Separan AP-30	Dow Chemical
Separan NP-10	Dow Chemical
Superfloc 16	Cyanamid

Analyses of flume wastes before treatment

pH - 6.6
turbidity - approximately 130 p.p.m.

Chemical	Dosage p.p.m.	Turbidity of Supernatant	pH	Remarks
1. Aerofloc 550	1	480	6.6	Turbidity measurements were made after the samples were allowed to stand 30 to 60 mins.
2. Aerofloc 3171	5	158	6.6	
3. Colloid 5S	10	205	-	
4. M-11	2	163	-	
5. M-11	5	128	-	
6. Separan AP-30	0.8	210	-	
7. Separan AP-30	1.0	188	-	
8. Separan AP-30	1.5	170	-	
9. Separan AP-30	2.0	140	-	
10. Separan NP-10	2.0	150	-	
11. Superfloc 16	1.5	160	-	* see note on page 3
Alum *	100	21		BOD - 165

TABLE IV

EFFECT OF VARYING DOSAGES OF POLYELECTROLYTES ON THE TURBIDITIES IN THE SUPERNATANT

Chemical	Dosage p.p.m.	Turbidity after 30 min.	Remarks
1. untreated		> 1000	practically no settling
2. Superfloc 16	0.2	370	some settling
3.	0.4	320	some settling
4.	0.6	290	a slight improvement in settling
5.	1.0	163	same as in (4) very rapid settling
6.	1.5	160	supernatant clarified within 3 min.
7.	2.0	135	same as in (6)
8.	3.0	125	best clarity

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All analyses except pH reported in p.p.m. unless otherwise indicated

SEWAGE ANALYSIS

1 p.p.m. = 1 mgm. / litre = 1 lb./100,000 Imp. Gals.

Municipality: Chatham   Report to: A. Oda. *   c.c.

Source: Canada & Dominion Sugar Co. Ltd. (settling tests)

Date Sampled: Nov. 13/63 by: Proctor & Redfern Ltd.

Lab. No.	5-Day B.O.D.	Solids				pH at Lab	Acidity as $CaCO_3$			
		Total	Susp.	Diss.						
10211	195	3134	2456	678	dried	6.9	130			
		690	216	474	ashed					
		2444	2240	204	loss					
10212	195	716	94	622	dried	6.8	110			

10211	Flume water (composite sample)
10212	Flume water (supernatant after 24-hour settling)

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All analyses except pH reported in p.p.m. unless otherwise indicated

SEWAGE ANALYSIS

1 p.p.m. = 1 mgm. / litre = 1 lb./100,000 Imp. Gals.

Municipality: Chatham

Report to: A. Oda *

c.c.

Source: Canada & Dominion Sugar Co. Ltd. (Coagulation Tests)

Date Sampled: Nov. 20/65

by: G. Foster

Lab. No.	5-Day B.O.D.	Solids				Turbidity as Silica Units	pH			
		Total	Susp.	Diss.						
10343	230					> 800	6.6			
10344	195					158	6.5			
10345	180					74	6.4			
10346	225					58	6.3			
10347	165					28	6.1			
10348	150					26	6.3			
10349	165					21	6.3			

10343	Flume water - no treatment
10344	- after 24-hour settling
10345	- treated with 100 p.p.m. alum
10346	- treated with 125 p.p.m. alum
10347	- treated with 175 p.p.m. alum
10348	- treated with 100 p.p.m. alum and 2 p.p.m. activated silica
10349	- treated first with 2 p.p.m. Superfloc 16 and the supernatant was given further treatment with 100 p.p.m. alum.

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